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ABSTRACT

This document advances the premise that the scientific method to identify cause-effect relationships is undoubtedly the single most important factor in the geometric expansion of scientific advances evidenced thus far during the 20th century. To understand these advances and to make educated decisions concerning them, the citizenry must be scientifically literate. It is further argued that to be scientifically literate, individuals must understand the scientific process. The materials provide an example of an investigation which employs the scientific method to learn about some aspects of sound. Once data are collected, as a result of student investigation, they are computerized as a method of identifying trends. In the investigation students use active inquiry, group processes and Piagetian principles to determine how various factors interact to produce the pitch one hears. The investigation is an extension of the one where all jar or glass sizes are identical and, therefore, the glass size variable automatically controlled. A set of instructions for developing AppleWorks data base computer files (comprising four-fifths of the document) is attached. (PK)

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ED300210

JARS AND WATER, CONTROLLING VARIABLES IN THE STUDY OF SOUND USING A DATA TABLE AND A COMPUTER DATA BASE

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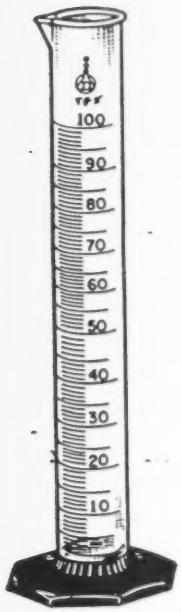

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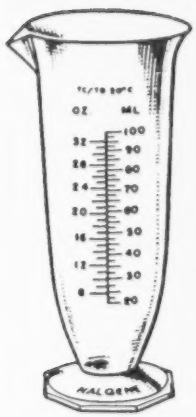

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INTRODUCTION

The scientific method as a process to identify cause-effect relationships is undoubtly the single most important factor in the geometric expansion of scientific advances evidenced thus far during the 20th century. To understand these advances and to make educated decisions concerning them our citizens must be scientifically literate and to be scientifically literate, they must understand the scientific process. We, therefore as teachers, must compell ourselves to teach and to use this process with our students whenever and wherever possible. The process is used in the following investigation to learn about some aspects of sound. Once data are collected, as a result of student investigation, they are computerized as a method of identifying trends.

OVERVIEW

Jars and Water, Controlling Variables In The Study Of Sound was designed for use starting at about grade three and continuing through college. In the investigation, students use active inquiry, group process and Piagetian principles to determine how various variables interact to produce the pitch one hears. The investigation is an extention of the one where all jar or glass sizes are identical and, therefore, the glass size variable automatically controlled. In this activity, the process is as important as the product.

Level. Grades 3 through college.

Science Principles.

1. Observing.
2. Hypothesizing.
3. Data Gathering.
4. Drawing Conclusions.
5. Data Manipulation.
6. Measuring.
7. Graphing Techniques.
8. Volumetric Measurement.
9. Controlling Variables.

Math Principles.

1. Computation of Area.
2. Volume Computation.
3. Calculus Principles.

Computer Principles.

1. Disk Formatting.
2. Program Loading.
3. File Storage.
4. File Construction.
5. File Printing.
6. Data Base Manipulation.

Partial List of Variables.

1. Volume of the jars.
2. Surface area of the water.
3. Water volume.

4. Volume of the air column above the water.

Materials (for each group of students, unless otherwise mentioned).

1. 3 jars of varing sizes (straight sided like peanut butter - straight sided water glasses will also work as long as they are random sizes.
2. 2 glass containers of identical size.
3. One pencil (per student).
4. Several sheets of paper.
5. One liter of water.
6. One volumetric measure per group (graduated cylinder or measuring cup).
7. One ruler per student.
8. At least one Apple IIe or GS computer with printer (for the entire class.
9. One blank computer floppy disk for each student.
10. One copy of the AppleWorks computer program for each computer.

Procedures.

1. Divide the class into groups of 3 - 4 students each.
2. Provide students with the necessary materials.
3. Allow approximately 5 minutes for student, using the materials provided, to see what they can learn about sound.
4. Conduct a brainstorming session where students suggest variables to investigate as they attempt to learn something about sound (guide the discussion so that the variables listed above are identified). Review the Formulas for area of a circle and volume of a cylinder (is not necessary below about grade 5 since students probably won't do the calculations).
5. List the suggestions on a chalkboard or flip chart.
6. Allow a second time period where students actively investigate sound based upon variables identified during the brainstorming session. You may want to suggest that students use a measuring cup or graduated cylinder as they search for answers.
7. Conduct a discussion where students present their

4. Volume of the air column above the water.

Materials (for each group of students, unless otherwise mentioned).

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5. List the suggestions on a chalkboard or flip chart.
6. Allow a second time period where students actively investigate sound based upon variables identified during the brainstorming session. You may want to suggest that students use a measuring cup or graduated cylinder as they search for answers.
7. Conduct a discussion where students present their findings. At this point, allow time to share data between groups. This will give each student and each group sufficient data so that trends should appear.
8. Have students draw conclusions regarding what they have learned about sound.
9. Allow a third period of active investigation during which students verify their conclusions. This is accomplished by listening to the pitch of the sound produced when jars of identical volume, filled with water to differing levels (the two identically sized jars), are struck with a pencil.
10. Have students organize their data using a table similar

to the one included at the end of this activity (you may want to students to make their own data table).

11. Computerize the findings using the Apple computer and the AppleWorks data base subprogram (directions used to accomplish this task are at the back of this writeup).
    a. Load the AppleWorks program into to the computer. The teacher may need to do this for younger students.
    b. Format the blank floppy disk. Teachers may need to do this for younger students. The task may be accomplished by selecting option 5, "Other Activities," from the AppleWorks "Main Menu" (see the instructions at the end of this paper).
    c. Construct a new data base file. Include variables in the file from the brainstorming session and the data table if applicable. To accomplish this task, the directions seen on the screen must be followed.
    d. Enter the data gathered during the data gathering session into the file (the file will have a record for each button).
    e. Store the file by pressing the OPEN-APPLE and the "S" keys at the same time.
    f. Print the file.
    g. Manipulate the file various ways using the OPEN-APPLE and "A" keys option.
    h. Print each new arrangement. See the instructions at the end of the activity
12. Allow students a period to examine data trends evidenced as a result of the computer data manipulations.

Background. Students, generally, will add varying amounts of water to the jars, tap the jars with a pencil and may rapidly conclude that the jar with the least water in it produces the highest pitch. This conclusion, however, may be faulty since it is the volume of the air column above the water that determines the pitch of the sound which is produced.

Curriculum Extension.

1. Write a report of the investigation using the AppleWorks word processing subprogram and the computer.
2. Write a story about the project using the computer.
3. Write a letter to a friend about the project. The letter is composed while using the computer.

DATA COLLECTION TABLE

JAR NO.	JAR VOLUME	WATER VOLUME	AIR VOLUME	WATER SURFACE AR.

INSTRUCTIONS FOR DEVELOPING APPLEWORKS

DATA BASE COMPUTER FILES

STEPS DIRECTIONS

01. Load the AppleWorks program into the computer. With this task completed, your screen should look like Figure 1 (the "Main Menu" is on the screen). In the upper left corner of the screen, you should find the numeral "2" following the second word "Disk." If this is the case, proceed to step 02. If the numeral is "1," go to step number 05.

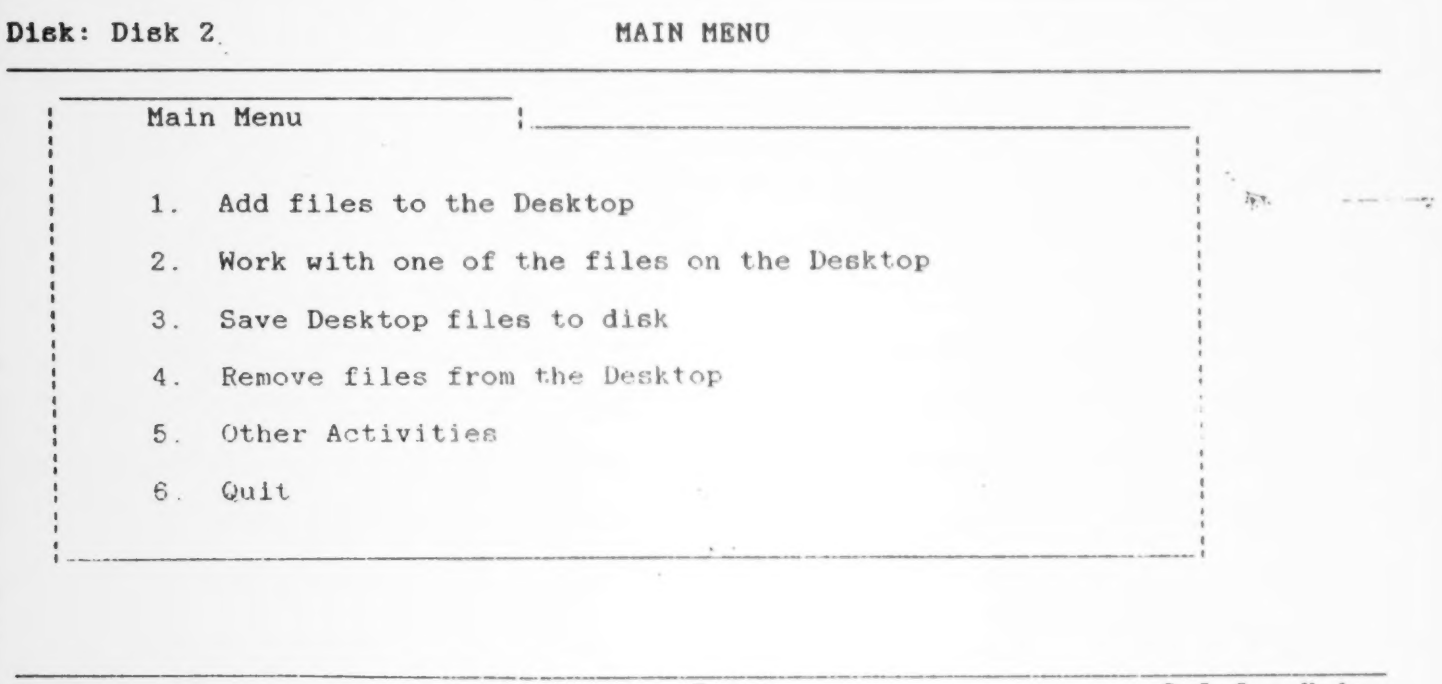
Disk: Disk 2
MAIN MENU
Main Menu
1. Add files to the Desktop
2. Work with one of the files on the Desktop
3. Save Desktop files to disk
4. Remove files from the Desktop
5. Other Activities
6. Quit
Type number, or use arrows, then press Return
@-? for Help

Figure 1. The Computer Screen With Disk Drive Two Selected.

02. Option #1, "Add Files to the Desktop" is high lighted (usually in green, but the actual color depends on the type of equipment you have) so you should press the RETURN key once. Your screen should look like the picture shown in Figure 2 following this action.

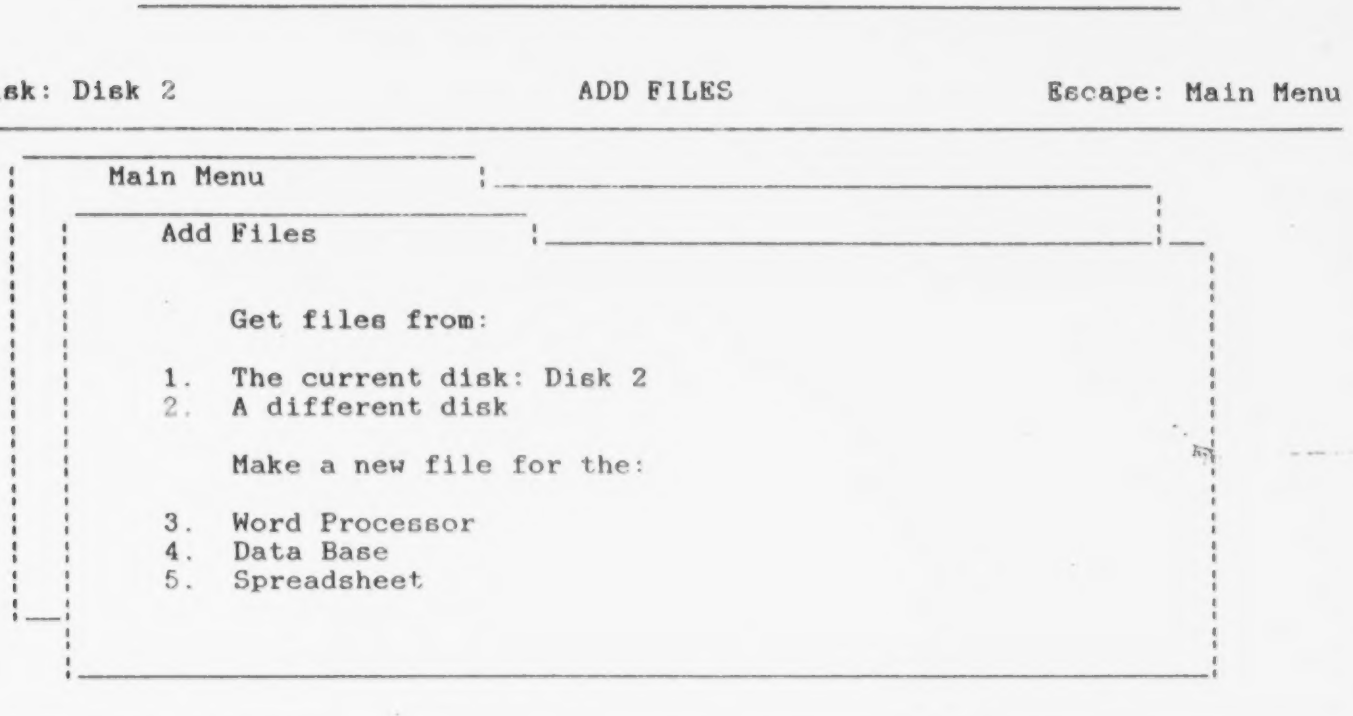

Figure 2. The Screen After Selecting, the "Add File to the Desktop" Option.

03. Press the numeral "4" key and then press the RETURN key once. This action should bring you to the "Data Base" menu and the screen will appear as does the picture in Figure 3.

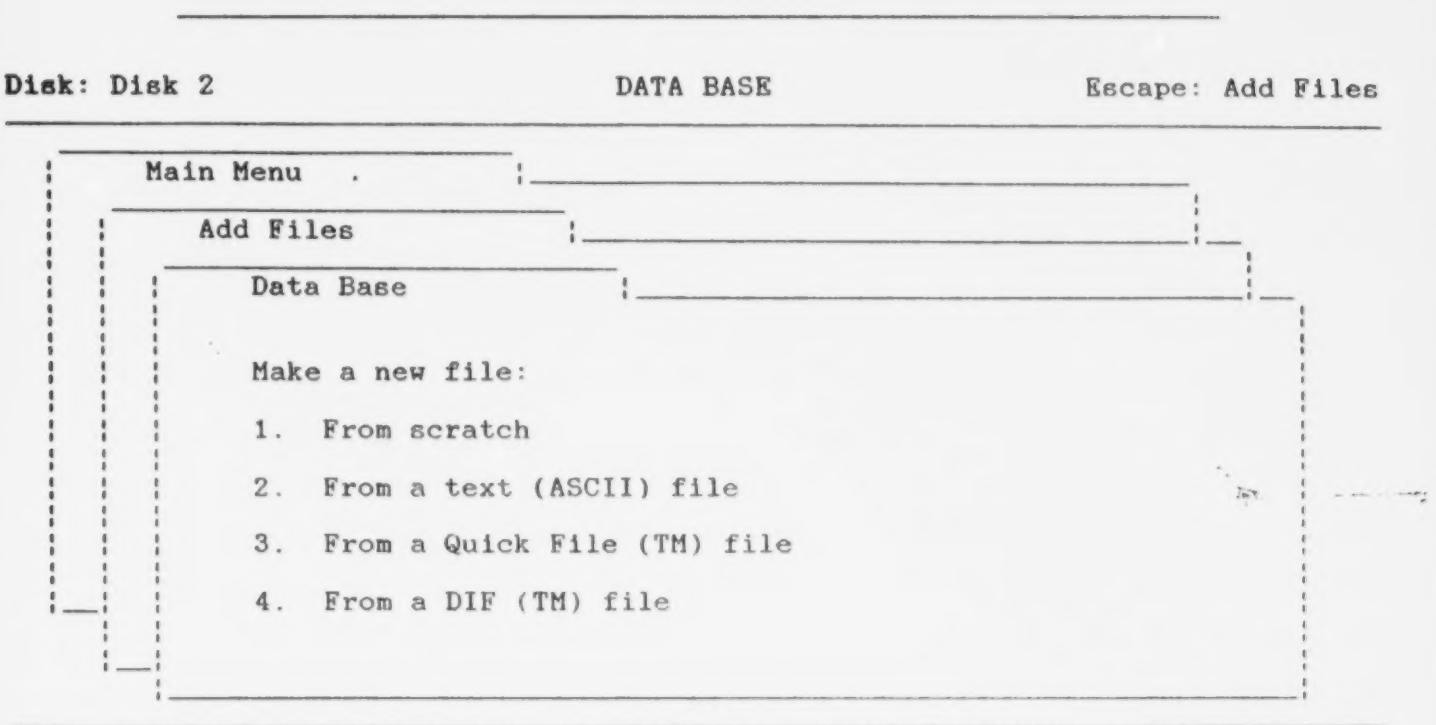

Figure 3. The "Data Base" Menu.

04. If you have successfully reached this point, jump to step 08.

05. If the screen looks like the picture shown in Figure 4 (note the #1 in the upper left corner of the Figure), select option #2, "A different disk," from the "Main Menu" by pressing DOWN ARROW once followed by RETURN once. As a result of this action, the screen should shift so that it appears like the picture shown in Figure 5.

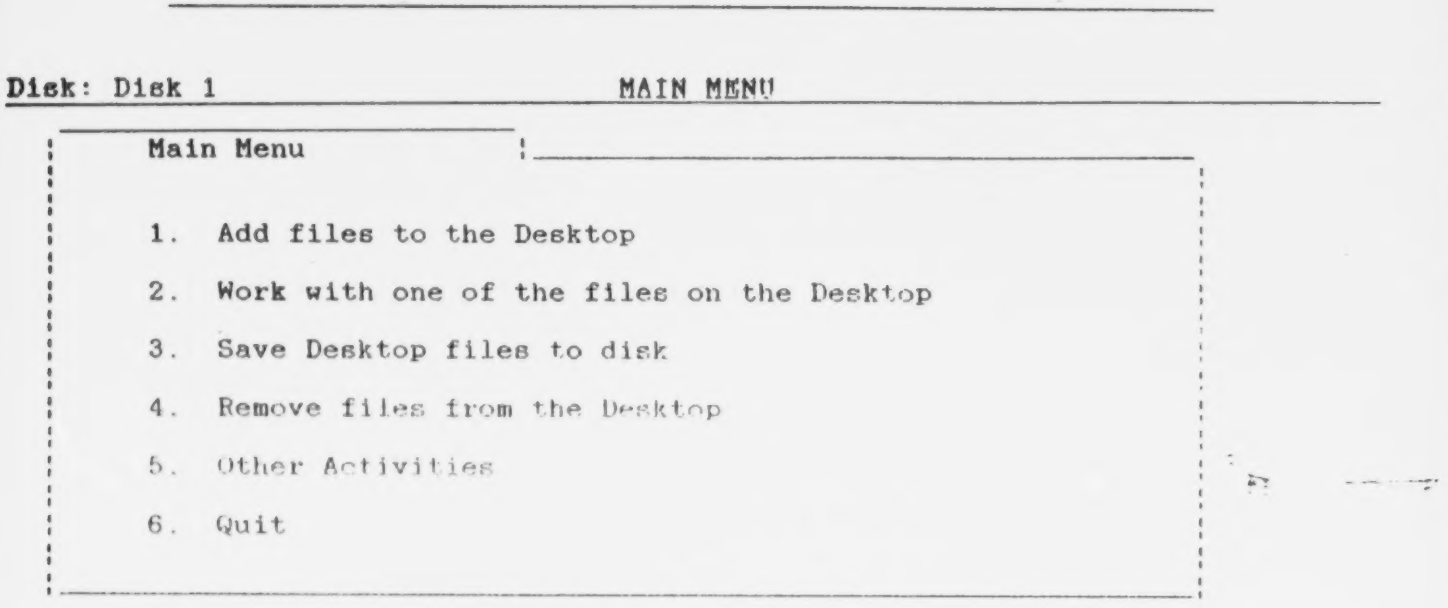
Disk: Disk 1
MAIN MENU
Main Menu
1. Add files to the Desktop
2. Work with one of the files on the Desktop
3. Save Desktop files to disk
4. Remove files from the Desktop
5. Other Activities
6. Quit
Type number, or use arrows, then press Return
@-? for Help

Figure 4. Computer Screen With "Disk: Disk 1" Selected.

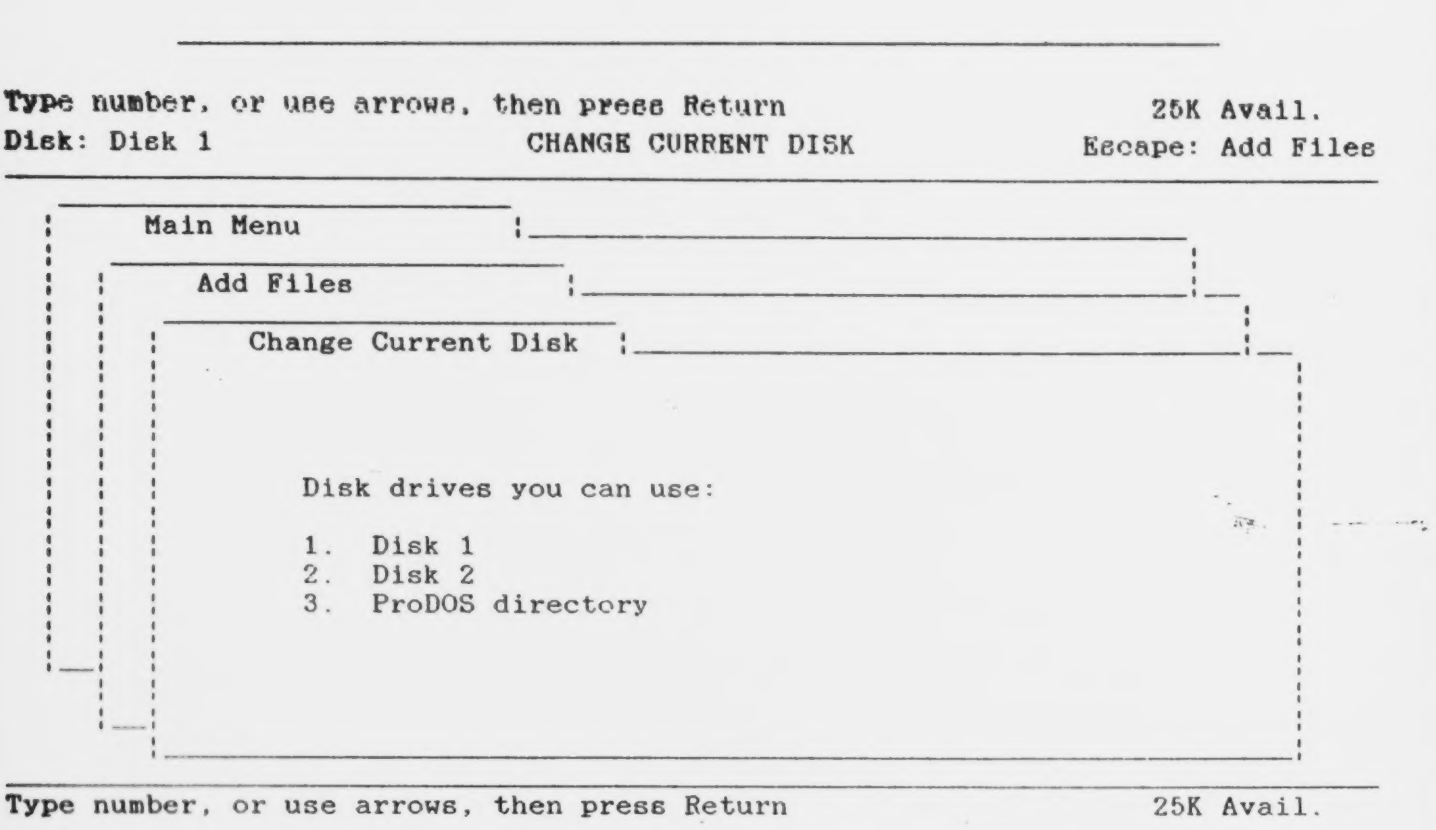

Figure 5. The Screen After Choosing, "A different disk" Option.

06. Select option #2, "Disk 2" by pressing DOWN-ARROW once followed by RETURN once. The screen should have changed following this action and now appear as it does Figure 2.

07. Now, complete step 03 and then jump to step 08.

08. With the screen appearing as it does in Figure 3 select option #1 (it is high lighted),"From scratch" by pressing RETURN once. The picture you see on the screen will change so that it looks like the one shown in Figure 6 below.

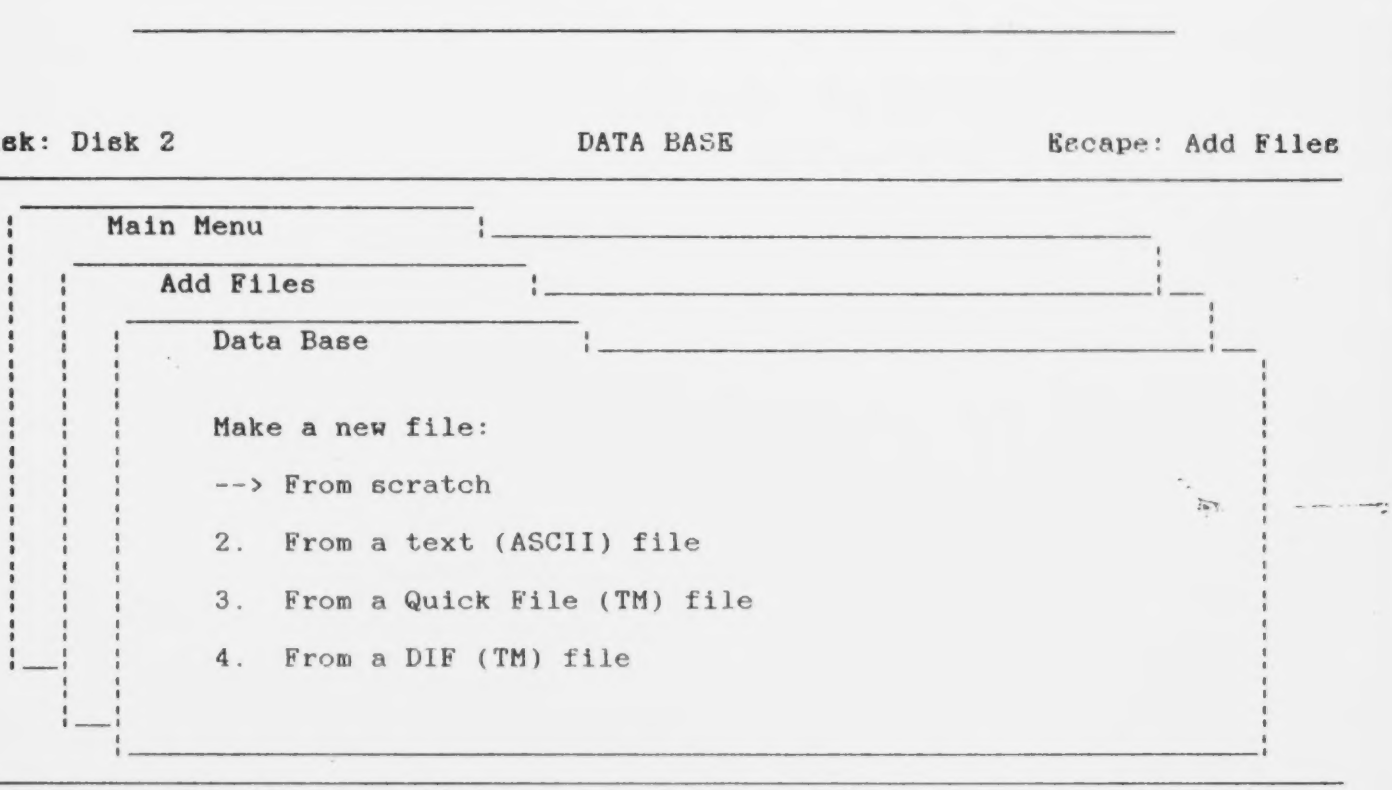

Figure 6. The Screen Showing The "From Scratch" Option Of The "Data Base" Menu Selected.

09. Directions at the bottom of the screen tell us to name the the new file so type the word "BUTTONS" (or some other name). The screen will now be identical to the picture shown in Figure 7.

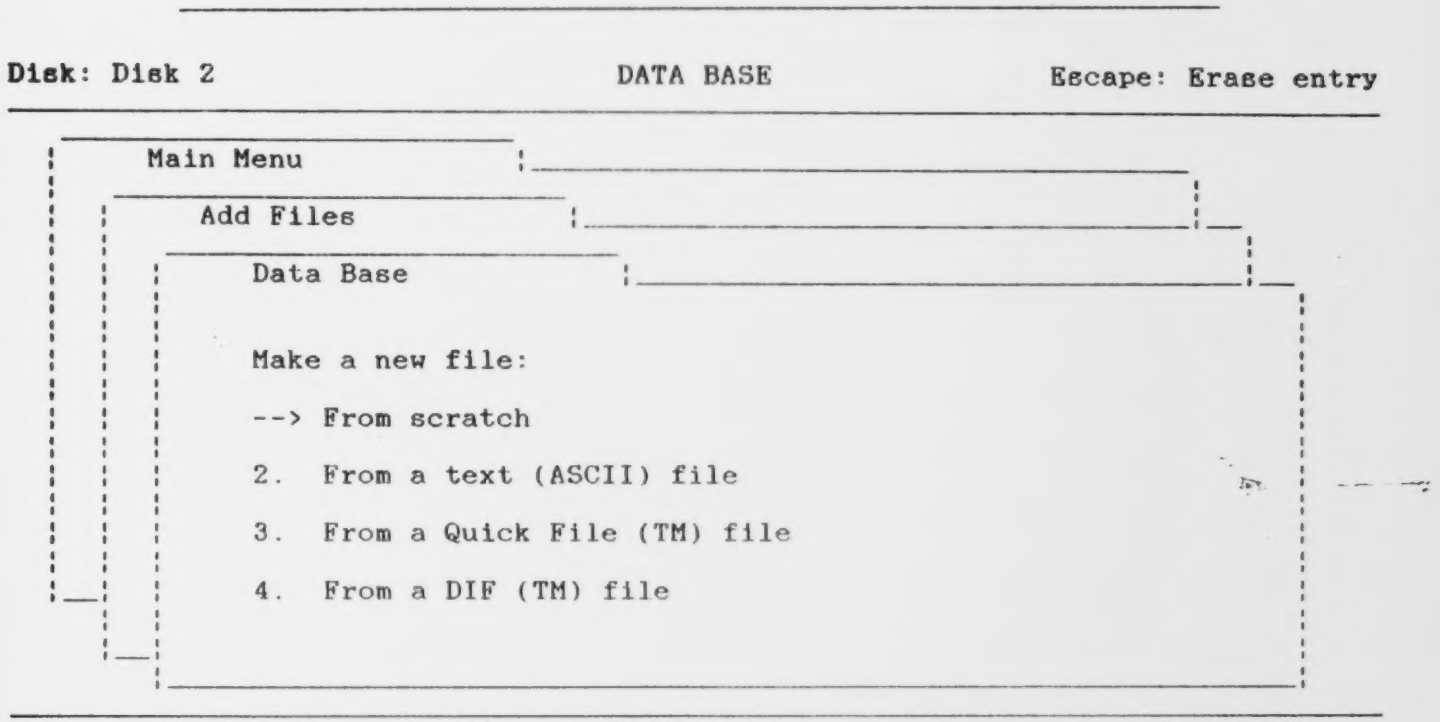

Figure 7. The Computer Screen After Naming The File.

10. Press the RETURN key once. The screen should look like the picture shown in Figure 8.

```
File: BUTTONS                  CHANGE NAME/CATEGORY    Escape: Review/Add/Change


Category names
================================================================================
Category 1                                  |
                                            |  Options:
                                            |
                                            |  Change category name
                                            |  Up arrow    Go to filename
                                            |  Down arrow  Go to next category
                                            |  @-I         Insert new category
                                            |
                                            |
                                            |
                                            |
                                            |
                                            |
--------------------------------------------------------------------------------
Type entry or use @ commands                                        55K Avail.
```

Figure 8. The Computer Screen Showing The Basic Data Base File Prior To The Insertion Of Category Names.

11. Insure that you are using the blinking block cursor and not the blinking line cursor. If the monitor screen shows a blinking line cursor, press the OPEN-APPLE and "E" keys at the same time to switch to the blinking block cursor (to switch back to the blinking block cursor, press the OPEN-ARROW and "E" keys at the same time).

12. Insert the first category name. This is accomplished as follows:

a. Press the CAPS-LOCK key down so that the machine will type only capital letters.

b. Type "SHAPE," (this data base will contain date derived from a random collection of buttons).

c. Press the SPACE-BAR several times to erase the remaining letters and numeral in the original "Category 1."

d. Press the RETURN key once. The screen should look like Figure 9.

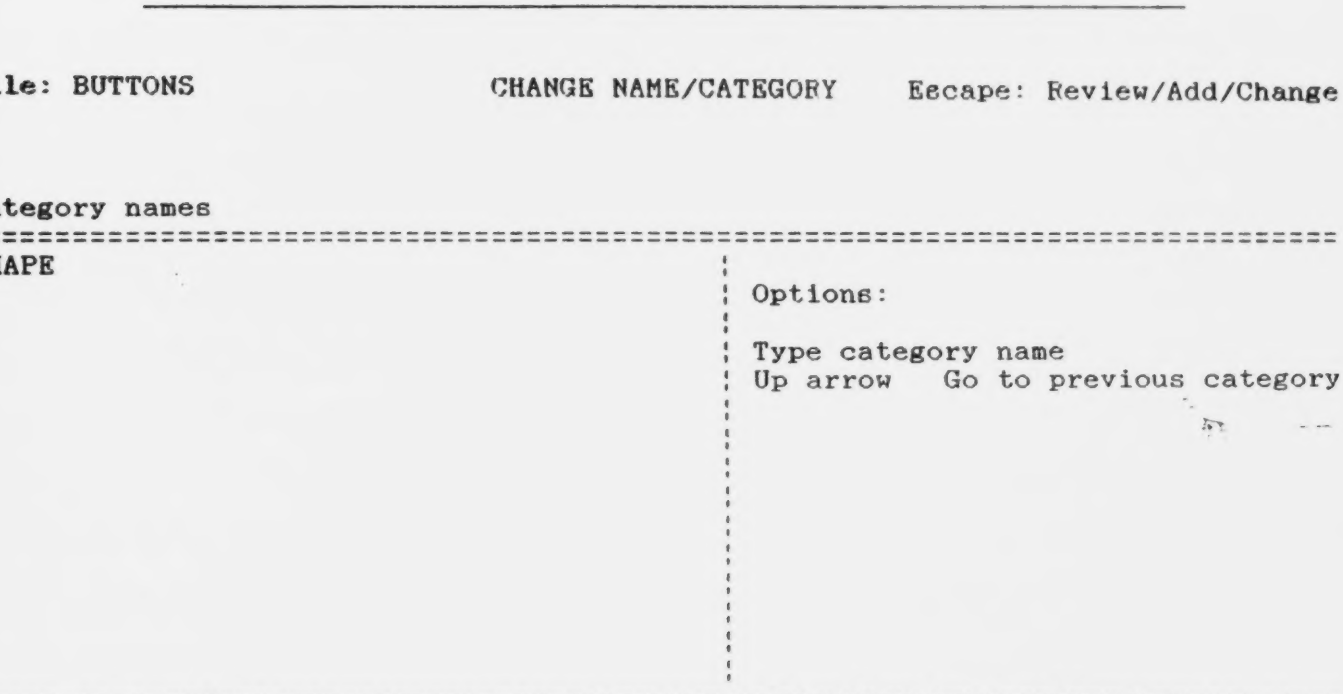

Figure 9. The Computer Screen After Inserting The "SHAPE category.

13. Type, "COLOR," and then press the RETURN key once.

14. Insert the following additional categories "COLOR, NUMBER, THICKNESS, TEXTURE, DIAMETER, LENGTH, WIDTH HOLES, AREA, VOLUME." Press the RETURN key once after typing each category name as was done above in step #13. The screen should look like the picture in Figure 10. At this point, the cursor is located on the line below "VOLUME."

```
File: BUTTONS                CHANGE NAME/CATEGORY     Escape: Review/Add/Change


Category names
================================================================================
SHAPE                                  |
COLOR                                  | Options:
NUMBER                                 |
THICKNESS                              | Type category name
TEXTURE                                | Up arrow   Go to previous category
DIAMETER                               |
LENGTH                                 |
WIDTH                                  |
HOLES                                  |
AREA                                   |
VOLUME                                 |
                                       |
--------------------------------------------------------------------------------
Type entry or use @ commands                                        54K Avail.
```

Figure 10. The Computer Screen After Typing The Eleven Category Names.

15. Press the ESC (escape) key once. The screen now looks like the picture shown in Figure 11.

```
File: BUTTONS                    REVIEW/ADD/CHANGE                Escape: Main Menu

Category names
==============================================================================

                    This file does not yet contain
                    any information.  Therefore, you
                    will automatically go into the
                    Insert New Records feature.

------------------------------------------------------------------------------
Press Space Bar to continue                                          51K Avail.
```

Figure 11. The Monitor Screen After Performing Step 15.

16. Press the SPACE-BAR once. The screen changes so that it appears like the screen shown in Figure 12 and the file is ready for the insertion of real data.

```
File: BUTTONS                    INSERT NEW RECORDS     Escape: Review/Add/Change


Record 1 of 1
================================================================================
SHAPE: -
COLOR: -
NUMBER: -
THICKNESS: -
TEXTURE: -
DIAMETER: -
LENGTH: -
WIDTH: -
HOLES: -
AREA: -




--------------------------------------------------------------------------------
Type entry or use @ commands                                        51K Avail.
```

Figure 12. The Computer Screen Showing A Blank "Record 1 of 1".

17. Insert data in the first record. This accomplished as follows:

    a. Type the information to be entered in a category.

    b. Press the RETURN key once.

c. Type information in the next category and press the RETURN key once. After inserting data in all categories, your screen should be similar to the picture shown in Figure 13.

File: BUTTONS REVIEW/ADD/CHANGE Escape: Main Menu

Selection: All records

Record 1 of 2

==========

SHAPE: Round
COLOR: Blue
NUMBER: 10
THICKNESS: 4mm
TEXTURE: Smooth
DIAMETER: 2.5cm
LENGTH: NA
WIDTH: NA
HOLES: 4
AREA: 4.91sqcm
VOLUME: 1.96cucm

Type entry or use @ commands @-? for Help

Figure 13. The Computer Screen Showing Record 1 Following The Insertion Of Data.

d. Use the UP-ARROW key after pressing the RETURN key to return to a category where a mistake has been made.

e. If the computer does not move automatically from record 1 to record 2 after data has been inserted in the last category (VOLUME) follow the directions provided on the monitor screen.

18. After inserting information in the first record, press the OPEN-APPLE and the "Z" (zoom) keys at the same time. The screen will now appear similar to the example provided in Figure 14 (if you want to return to the original format, press the OPEN-APPLE and the "Z" again).

File: BUTTONS REVIEW/ADD/CHANGE **Escape:** Main Menu

Selection: All records

SHAPE	COLOR	NUMBER	THICKNESS	TEXTURE
Round	Blue	10	4mm	Smooth
-	-	-	-	-

Type entry or use @ commands @-? for Help

Figure 14. The Computer Screen After Entering Data In The First Record And Switching Screen Formats.

19. Press the OPEN-APPLE and the "L" (layout) keys at the same time. This action will allow changes in the column widths and the like to be made. See Figure 15.

```
File: BUTTONS                    CHANGE RECORD LAYOUT     Escape: Review/Add/Change

================================================================================

                    --> or <--   Move cursor
                     >  @   <    Switch category positions
                    --> @  <--   Change column width
                    @-D          Delete this category
                    @-I          Insert a previously deleted category

--------------------------------------------------------------------------------

SHAPE          COLOR          NUMBER         THICKNESS      TEXTURE
-------------- -------------- -------------- -------------- --------------
Round          Blue           10             4mm            Smooth


-------------------------------------------------------------------- More --->
Use options shown above to change record layout                    51K Avail.
```

Figure 15. The Computer Screen After Selecting The Alter Layout Option.

20. Alter the file to fit your desires by following the directions provided on the screen. Figure 16 is an example of an altered file.

```
File: BUTTONS                    CHANGE RECORD LAYOUT    Escape: Review/Add/Change

================================================================================

                    --> or <--  Move cursor
                     >  @   <   Switch category positions
                    --> @  <--  Change column width
                    @-D         Delete this category
                    @-I         Insert a previously deleted category

--------------------------------------------------------------------------------

SHAPE COLOR NUMBER THICKNESS TEXTURE DIAMETER LENGTH WIDTH HOLES AREA    VOLUME
----- ----- ------ --------- ------- -------- ------ ----- ----- ------- ------
Round Blue  10     4mm       Smooth  2.5cm    NA     NA    4     4.91sqc 1.96cu


--------------------------------------------------------------------- More --->
Use options shown above to change record layout                    51K Avail.
```

Figure 16. Example Of An Altered File.

21. Press the ESC key once. The screen will appear similar to the example shown in Figure 17.

File: BUTTONS CHANGE RECORD LAYOUT Escape: Review/Add/Change

==========

What direction should the cursor
go when you press Return?

1. Down (standard)
2. Right

SHAPE	COLOR	NUMBER	THICKNESS	TEXTURE	DIAMETER	LENGTH	WIDTH	HOLES	AREA	VOLUME
Round	Blue	10	4mm	Smooth	2.5cm	NA	NA	4	4.91sqc	1.96cu

More --->

Type number, or use arrows, then press Return 51K Avail.

Figure 17. The Computer Screen After Pressing ESC Once.

22. Press the ESC key once (a second time). The monitor screen changes to appear similar to the example in Figure 18.

File: BUTTONS REVIEW/ADD/CHANGE Escape: Main Menu

Selection: All records

SHAPE	COLOR	NUMBER	THICKNESS	TEXTURE	DIAMETER	LENGTH	WIDTH	HOLES	AREA	VOLUME
Round	Blue	10	4mm	Smooth	2.5cm	NA	NA	4	4.91sqc	1.96cu
-	-	-	-	-	-	-	-	-	-	-

Type entry or use @ commands @-? for Help

Figure 18. The Monitor Screen Showing The Altered Data Base file.

23. Press the OPEN-APPLE and the "S" keys at the same time to save the file on a the data disk in slot or drive two.

24. Return to the "Main Menu" by pressing the ESC key once. The Screen now should be identical to the picture shown in Figure 19.

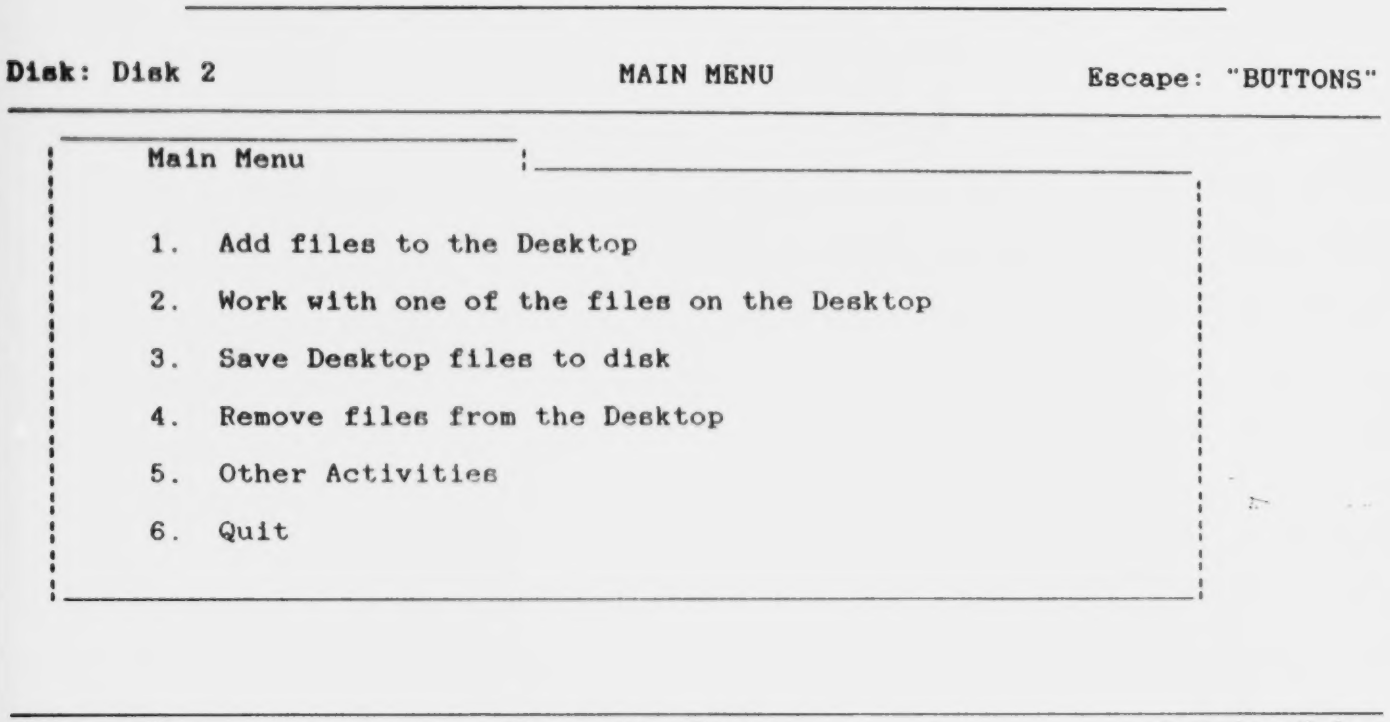
Disk: Disk 2
MAIN MENU
Escape: "BUTTONS"
Main Menu
1. Add files to the Desktop
2. Work with one of the files on the Desktop
3. Save Desktop files to disk
4. Remove files from the Desktop
5. Other Activities
6. Quit
Type number, or use arrows, then press Return
@-? for Help

Figure 19. "Main Menu."

INSTRUCTIONS FORMATTING BLANK FLOPPY

COMPUTER DISKS

USING

APPLEWORKS

STEPS **DIRECTIONS**

01. Load the AppleWorks program into the computer. With this task completed, your screen should look like Figure 1 (the "Main Menu" is on the screen). In the upper left corner of the screen, you should find the numeral "2" following the second word "Disk." If this is the case, proceed to step 02. If the numeral is "1," go to step number 04.

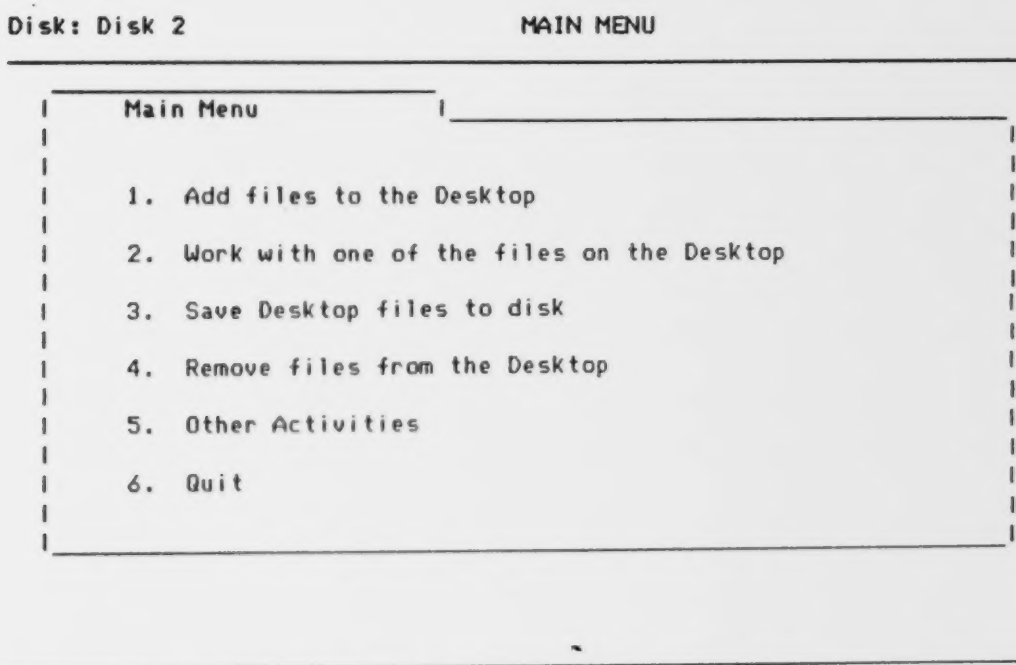
Disk: Disk 2
MAIN MENU
Main Menu
1. Add files to the Desktop
2. Work with one of the files on the Desktop
3. Save Desktop files to disk
4. Remove files from the Desktop
5. Other Activities
6. Quit
Type number, or use arrows, then press Return
?-? for Help

Figure 1. The Computer Screen With Disk Drive Two Selected.

02. Choose option #5, " Other Activities" from the "Main Menu." This is accimplished as follows:

a. Press the NUMBER-5 key once.

b. Press the RETURN key once. Your screen should look like the picture shown in Figure 2 following this action.

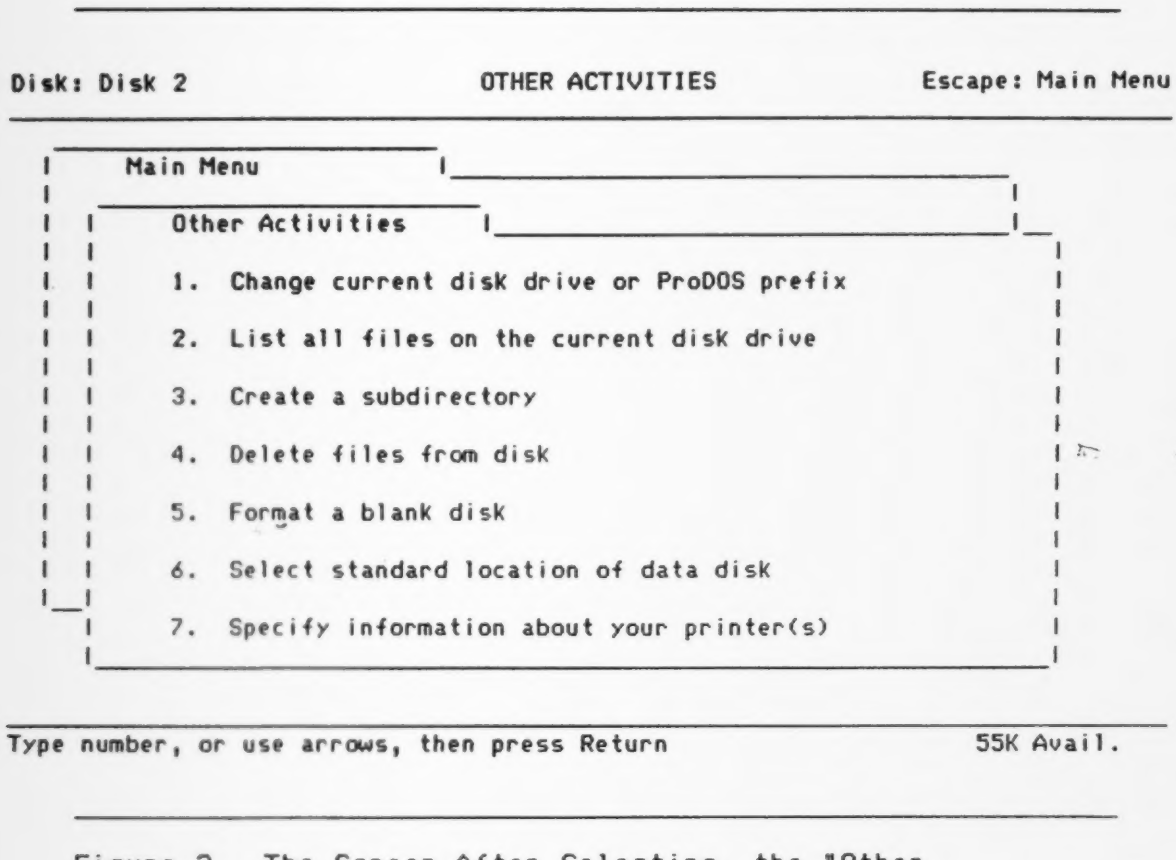
Disk: Disk 2
OTHER ACTIVITIES
Escape: Main Menu
Main Menu
Other Activities
1. Change current disk drive or ProDOS prefix
2. List all files on the current disk drive
3. Create a subdirectory
4. Delete files from disk
5. Format a blank disk
6. Select standard location of data disk
7. Specify information about your printer(s)
Type number, or use arrows, then press Return
55K Avail.

Figure 2. The Screen After Selecting, the "Other Activities" Option From The "Main Menu."

03. If you have successfully reached this point, jump to step 08.

04. If the screen looks like the picture shown in Figure 3 (note the #1 in the upper left corner of the Figure), select option #1, "Add files to the Desktop," from the "Main Menu." This is accomplished as follows:

a. Press the RETURN key once. Following this action, the screen should shift so that it appears like the picture shown in Figure 4.

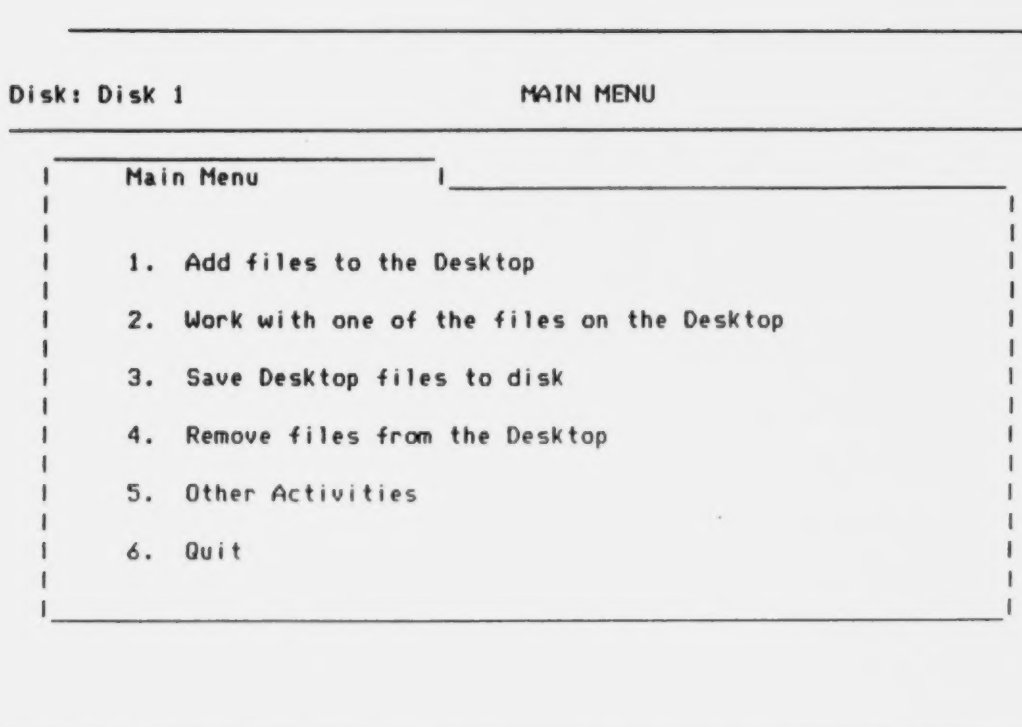
Disk: Disk 1
MAIN MENU
Main Menu
1. Add files to the Desktop
2. Work with one of the files on the Desktop
3. Save Desktop files to disk
4. Remove files from the Desktop
5. Other Activities
6. Quit
Type number, or use arrows, then press Return
?-? for Help

Figure 3. Computer Screen With "Disk: Disk 1" Selected.

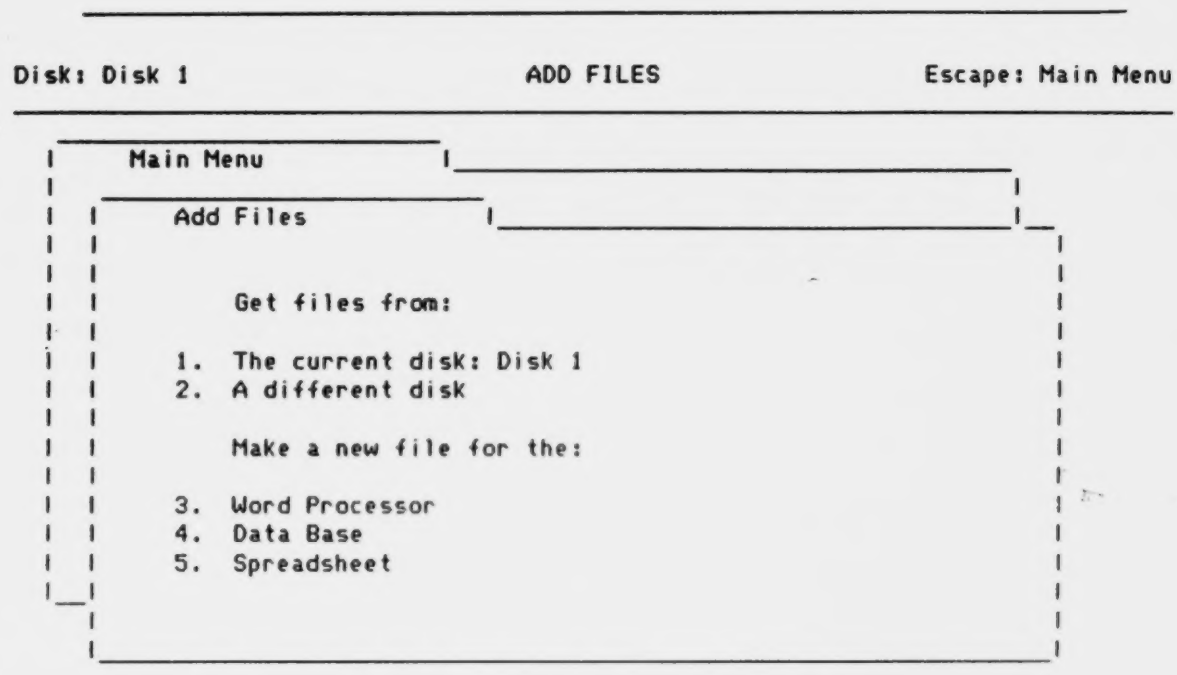

Figure 4. The Screen After Choosing, "Add files to the Desktop" Option From The "Main Menu".

05. Select option #2, "A different disk" from the "Add Files" menu as follows:

a. Press the DOWN-ARROW key once.

b. Press the RETURN key once. The monitor screen should look like the picture shown in Figure 5.

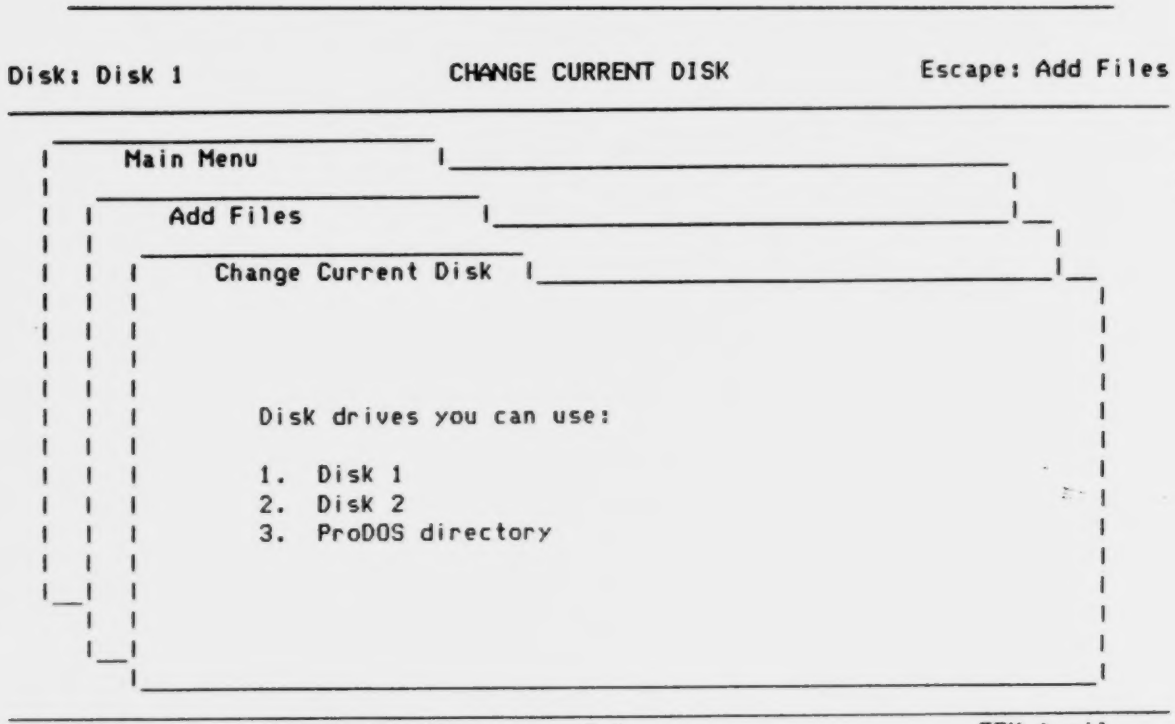

Figure 5. The Monitor Screen After Selecting The "A different disk" Option.

06. Select option 2, "Disk 2" as follows:

a. Press the DOWN-ARROW key once.

b. Press the RETURN key once. The screen should have changed following this action so that it appears as it did in Figure 4 except that the numeral "1" in the upper left corner of the screen has changed to "2."

07. Now, complete step 02 and then jump to step 08.

08. With the screen appearing as it does in Figure 2 select option #5 as follows:

a. Press the DOWN-ARROW until the "Format a blank disk" option is highlighted.

b. Press the RETURN key once. The picture you see on the screen will change so that it looks like the one you now see below in Figure 6.

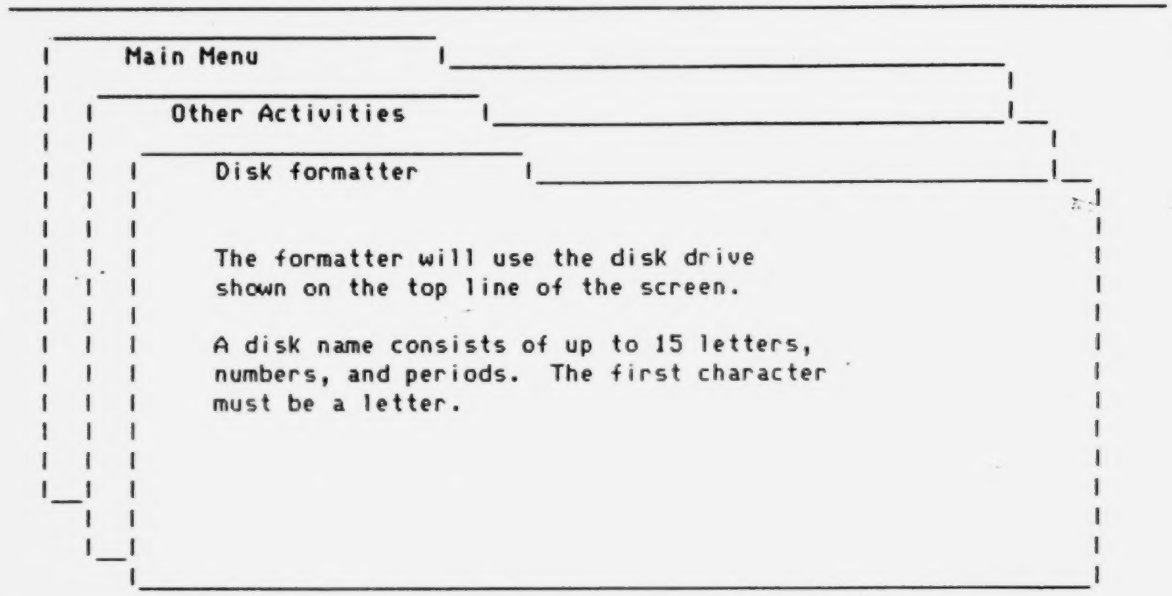
Disk: Disk 2
DISK FORMATTER
Escape: Other Activities
Main Menu
Other Activities
Disk formatter
The formatter will use the disk drive shown on the top line of the screen.
A disk name consists of up to 15 letters, numbers, and periods. The first character must be a letter.
Type a disk name:
55K Avail.

Figure 6. The Screen After Selecting the "Format a blank disk" Option From The "Other Activities" Menu.

09. Directions in the center of the screen tell you to name the the new disk so type "TRAINING" and then press the RETURN key once. The screen will now be identical to the picture shown in Figure 7.

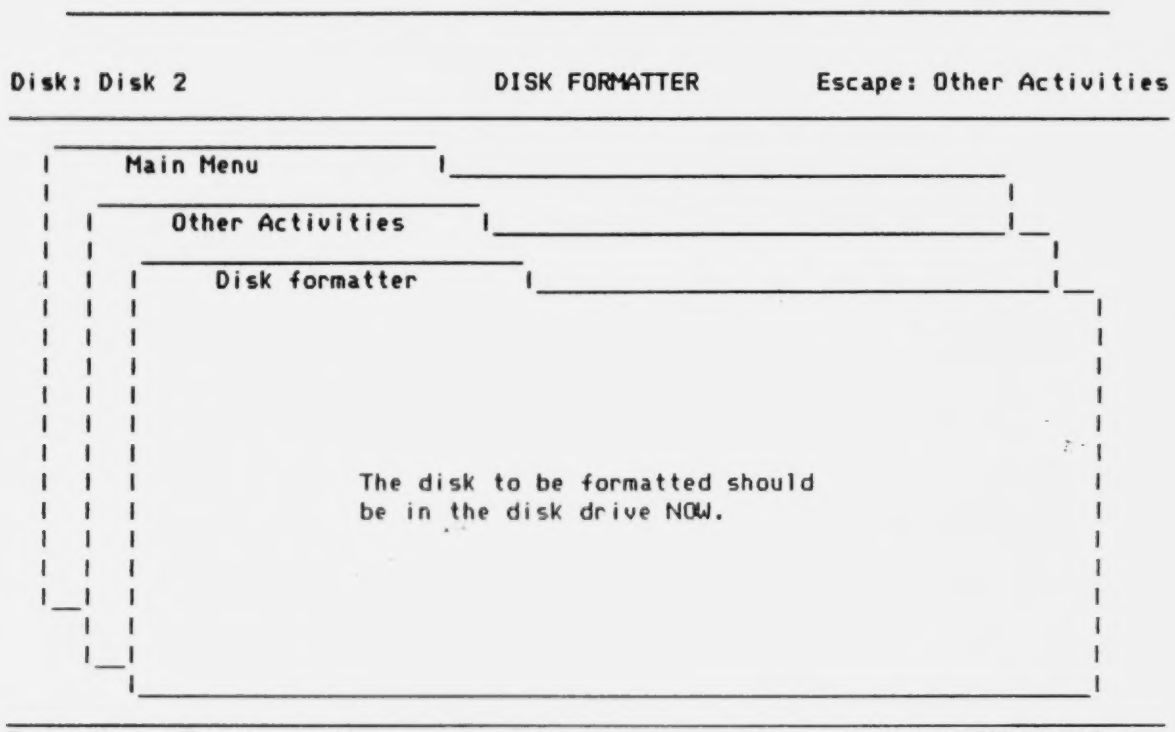

Figure 7. The Monitor Screen After Typing The Name Of The New Disk.

10. Insert the disk to be formatted in drive slot #2 or disk drive #2.

11. Press the SPACE-BAR and watch the screen. When the formatting task is complete, the monitor screen will appear like the example shown in Figure 8.

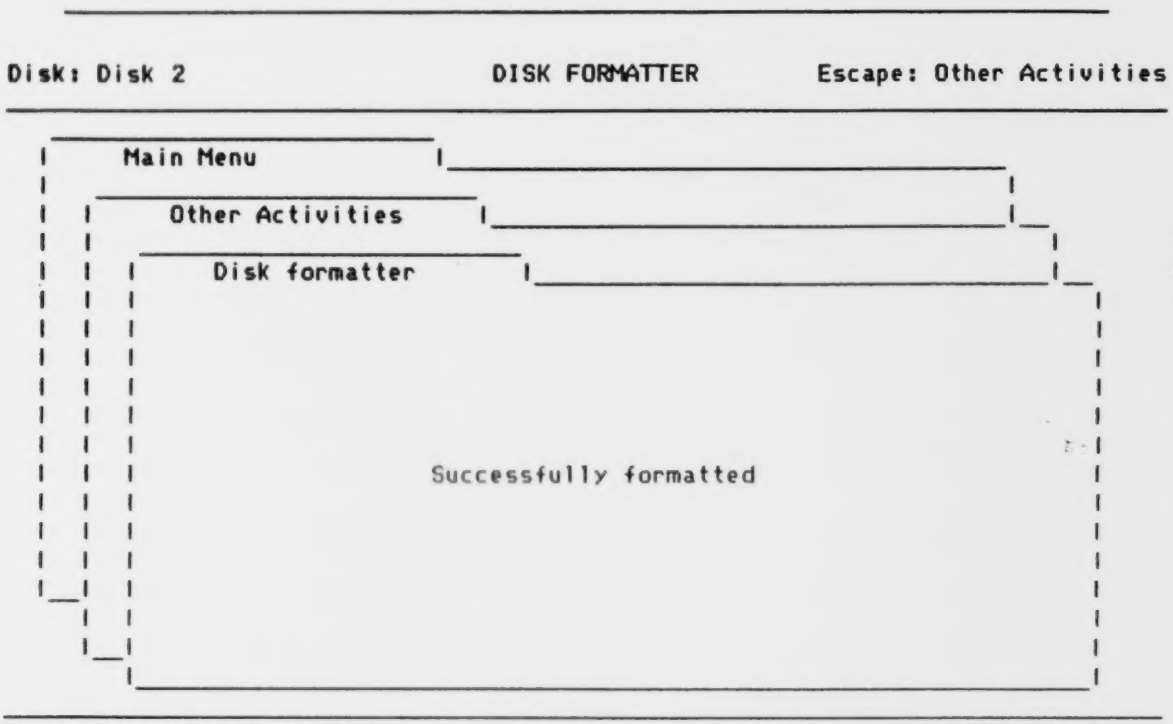

Figure 8. Monitor Screen After The Formatting Task Has Been Completed.

12. Press the SPACE-BAR once. The screen now looks like the example in Figue 9.

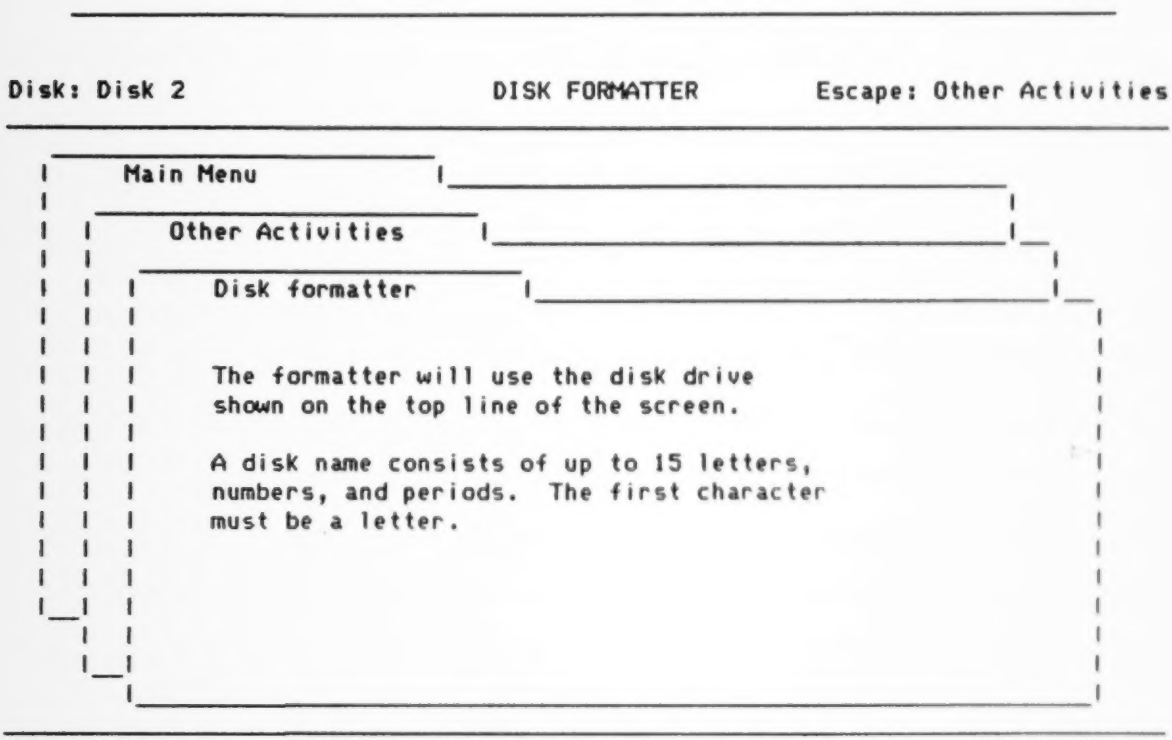
Disk: Disk 2
DISK FORMATTER
Escape: Other Activities
Main Menu
Other Activities
Disk formatter
The formatter will use the disk drive
shown on the top line of the screen.
A disk name consists of up to 15 letters,
numbers, and periods. The first character
must be a letter.
Type a disk name: TRAINING
55K Avail.

Figure 9. Monitor Screen After Exiting The Successfully Formatted Mode

13. Press the ESCAPE key once. This action should move the program back to the "Other Activities," menu (see Figure 10).

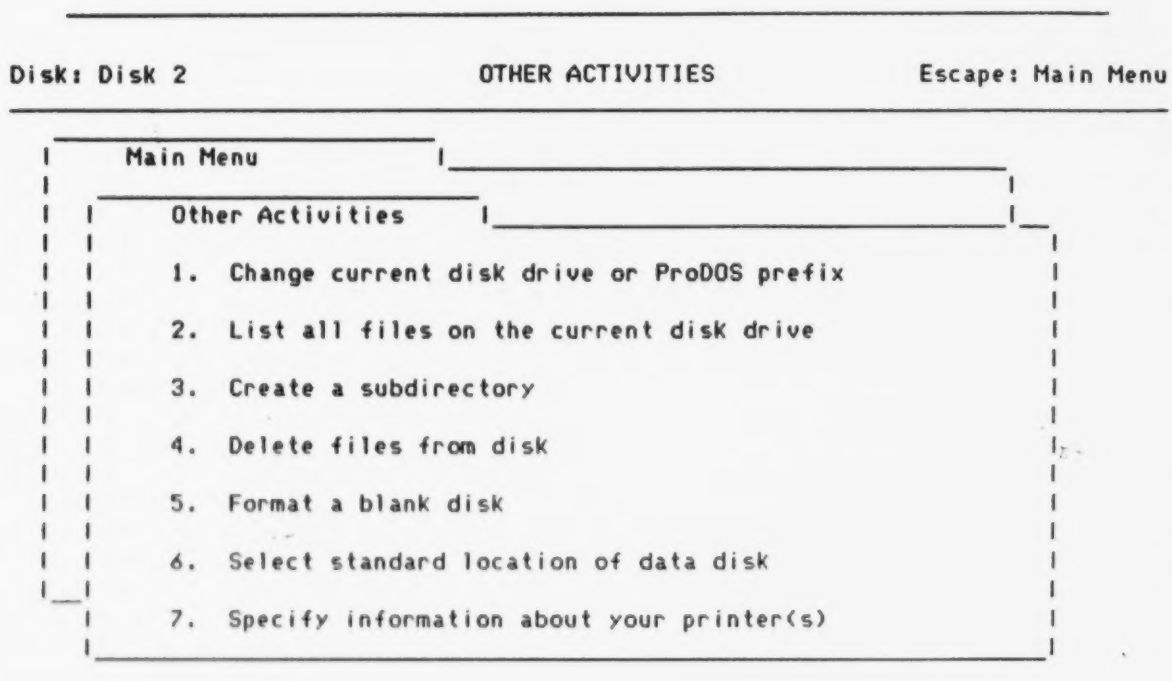
Disk: Disk 2
OTHER ACTIVITIES
Escape: Main Menu
Main Menu
Other Activities
1. Change current disk drive or ProDOS prefix
2. List all files on the current disk drive
3. Create a subdirectory
4. Delete files from disk
5. Format a blank disk
6. Select standard location of data disk
7. Specify information about your printer(s)
Type number, or use arrows, then press Return
55K Avail.

Figure 10. "Other Activities" Menu.

14. Press the ESCAPE key to move back to the "Main Menu" (see Figure 11).

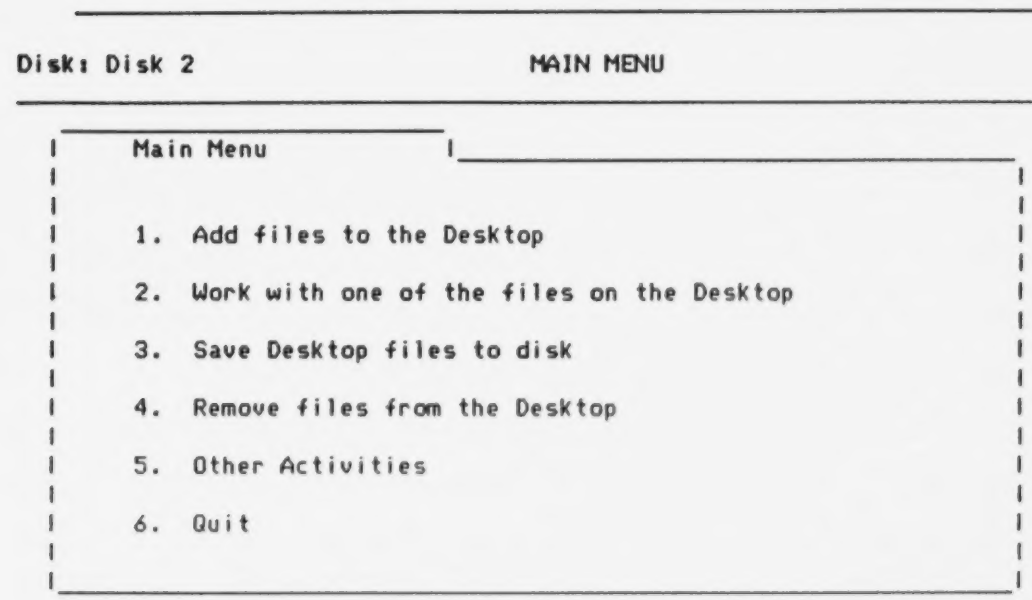
Disk: Disk 2
MAIN MENU
Main Menu
1. Add files to the Desktop
2. Work with one of the files on the Desktop
3. Save Desktop files to disk
4. Remove files from the Desktop
5. Other Activities
6. Quit
Type number, or use arrows, then press Return
?-? for Help

Figure 11. "Main Menu."